REPORT

ON THE

ECONOMICAL GEOLOGY

OF SOUTHERN OHIO,

TRAVERSED BY THE

MARIETTA & CINCINNATI RAILROAD,

INCLUDING THE PORTSMOUTH BRANCH,

BY

E. B. ANDREWS,

PROF. OF GEOLOGY, &C., MARIETTA COLLEGE, MARIETTA, OHIO.

CINCINNATI:
STEAM PRINTING HOUSE, FOURTH AND VINE STREETS.
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MARIETTA COLLEGE, April 7, 1865.

NOAH L. WILSON, ESQ., *President Marietta & Cincinnati R. R.:*

SIR: At your request I have made an examination of the mineral resources of the country traversed by your road and beg leave to submit the results in the accompanying report. The time allowed me was very limited, but nevertheless I have been able to gather and present many facts of the highest importance relative to the coal, iron ore, salt, petroleum, &c., found in the vicinity of your road. Trusting that my labors may aid somewhat in calling attention to the almost inexhaustible mineral wealth of this region, I am, very respectfully,

Your obedient servant,

E. B. ANDREWS.

REPORT.

The region of Ohio traversed by the Marietta and Cincinnati Railroad belongs to three distinct geological formations, viz.: the Silurian, Devonian and Carboniferous.

The *Silurian* rocks are found on the west end of the road from Cincinnati to the vicinity of Leesburg, in Highland county. The Silurian limestones in their disintegration constitute the richest and most productive soils, and no region in the land possesses greater agricultural resources.

The *Devonian* rocks extend eastward to the vicinity of Raysville, in Vinton county. By the Ohio Geological Reports these rocks are divided into three groups, viz: the Cliff Limestone, the Black Slates and the Waverly Sandstones. In the New York Geological Reports these rocks, as investigated in that State, are differently subdivided and named. Until our Ohio rocks are more carefully studied it will be difficult to apply, with entire accuracy, the names of the supposed New York equivalents. The Ohio Black Slates are doubtless the equivalent of the Hamilton group of New York, and the Waverly Sandstones are the Chemung and Portage groups of New York. A careful study of the fossils will alone determine the minuter points of correspondence.

The *Cliff Limestone*, when disintegrated and decomposed, forms an excellent soil, and the region bordering your road in which these limestones prevail must afford much traffic in the transportation of its agricultural products. This limestone is now largely burned into quicklime. The quality is represented as excellent, and the demand increasing. The supply is inexhaustible.

The *Black Slates* which appear low in the hills near Chillicothe, and extend westward ten or twelve miles, are probably two hundred and fifty feet thick. The sandstones which cap all the hills near Chillicothe belong to the Waverly group. The Black Slate being bituminous may prove to be of much econo-

mic value, as the source of petroleum, which rising accumulates in the fissures in the overlaying sandstones and shales. This point will be discussed under the topic of petroleum. The Black Slate has no value as coal, and all efforts to open coal mines in it will prove futile. The slate often burns with considerable bituminous flame, but when the bitumen is burned out there is no remaining coke to give heat. Nothing remains but lumps of slate in their original form. The time may come when oil may be distilled from it, but there are so many cannel coals richer in oil that that time is probably distant.

The *Waverly Sandstones* extend from the vicinity of Chillicothe to the neighborhood of Raysville. These sandstones when disintegrated make a poor soil, but fortunately in the valley of the Scioto, the underlying rock is covered with the richest alluvium brought down from the north. In addition to this alluvium are the terraces on the Scioto which are made up of the sands and gravels of the more northern drift. As these gravels are largely limestone in their composition, these terraces or plains are very rich and productive and yield enormous crops of corn. This simple fact explains the marvellous fertility of the Pickaway and other plains along the Scioto valley. Many of the strata of the Waverly Sandstones are peculiarly adapted to the purposes of building, and most valuable quarries are now wrought in the valley of the Scioto, and on the Ohio river, where this formation crosses into Kentucky. The name of the group is derived from Waverly, a locality in Pike county, where the sandstone has been largely quarried. It is a beautiful, fine-grained rock, easily quarried and wrought for architectural purposes. While the soil made by the disintegration of the Waverly rocks is generally poor in quality, yet it is thought to be peculiarly well adapted to the grape, and to fruit culture generally. Some of the finest peach orchards in the West are planted in the Waverly hills, and the southern and eastern slopes are thought to be well adapted to grapes. In the neighborhood of the Ohio river extensive vineyards are now being established among the hills of this group.

Conglomerate.—This rock, which is generally coarser in material than the adjacent sandstones, is found between Raysville and Cincinnati Furnace. It is above the conglomerate that we find the productive coal measures. The value of the conglomerate as the saliferous rock of Ohio will be described under its appropriate head.

Carboniferous.—Coal.—We find the coal first appearing in the hills in the vicinity of the Cincinnati Furnace, a few miles east of Raysville. Here the coal seams are thin, although under favorable circumstances they might be worked at a profit. Further examinations in the neighborhood might reveal greater thickness. On Pigeon Creek, south of Cincinnati Furnace, the lowest seam of coal lies a few feet above the conglomerate, and is, where mined, (on the land of Jacob A. Sell,) thirty-eight inches in thickness. The upper six inches are cannel coal of fine quality. The lower part, that is, the bituminous coal, judging by the sample obtained by my assistant, is of very superior quality and unusually free from bisulphuret of iron. This seam of coal is probably the same as the one now being opened on Salt Creek, three miles west of Jackson, by the Diamond Furnace Company, and also the same as the shaft seam now mined about 30 feet below the surface of the ground at Jackson. The reasons for this opinion are,

First. The geological position of each in its relation to the underlying conglomerate.

Second. There is, over the coal in the shaft at Jackson, a peculiar bluish, arenaceous shale, twenty-two feet thick. My assistant reports that he found a similar shale over the coal at the mine of Mr. Sell, on Pigeon Creek. The fire-clays and shales under the coal also correspond in character.

Third. In the small specimens of the several coals furnished me, a similarity was observed; but this evidence is not conclusive, as the specimens have not been analyzed. It is probable that a seam of coal found near the bed of the stream on the farm of Dr. Wolf, two or three miles northwest of McArthur, is the equivalent of the same seam. The same coal is reported to be found much higher up the hills several miles west of McArthur. It is the lowest workable seam in the coal measures, and, although not yet tried in a large way, it is believed to be peculiarly adapted to the reduction of iron ore. It has the same geological position as the famous Briar Hill Coal, of the Mahoning Valley, and has a remarkable resemblance to it in chemical characteristics. The analyses are as follows:

Shaft coal, Jackson.		Briar Hill coal, Youngstown.	
Bitumen	34.45	Bitumen	35.966
Fixed Carbon	63.04	Fixed Carbon	61.244
Ash	2.51	Ash	2.790
	100.00		100.000
Coke	65.55	Coke	64.034

Both varieties of coal are represented to be remarkably free from bi-sulphuret of iron.

Prof. J. S. Newberry, of Cleveland, Ohio, an eminent geologist, who analyzed the Briar Hill Coal, says in his "Report on the Economical Geology of the route of the Ashtubula and New Lisbon Railroad:" "The coke is hard and bright, retaining to some extent the form of the coal. Ash, light yellow, aluminous; contains very little iron; will not readily clinker. This coal yields 3½ cubic feet good gas per pound. We find it at a somewhat variable distance above the conglomerate, but generally within fifty feet, and from its peculiar qualities and its proximity to the lake market, it is, perhaps, the most important and valuable of the series. This seam of coal is traceable throughout nearly the entire line of out-crop of the coal basin in Ohio, and has, everywhere, certain characteristics which distinguish it from all others. * * * * This stratum is worked at Tallmadge, in Summit county, at Massilon, Stark county, in the vicinity of Sharon, Pa., and still more extensively in the Mahoning Valley—where it is known as the 'Briar Hill, or Mahoning Valley Coal'—and from whence it has been largely exported to Cleveland, commanding the highest price of any coal sold in that market. * * * * This enjoys the honor of being the only western coal as yet successfully employed in the raw state in the reduction of iron by means of the hot blast; and many thousand tons of iron are annually manufactured through its agency by this process. Aside from the manufacture of metals, to which this coal is peculiarly adapted, it answers well for the generation of steam, especially where the draft is not strong; its open-burning quality giving free passage to the air, and preventing the clogging of the grates. It is, therefore, preferable as a steam coal on the lakes to any other variety. When the draft is strong a more adhesive coal will be found more economical and should be used."

The Jackson Shaft Coal has been successfully tried in the coal-burning locomotives on the M. & C. R. R. This is regarded as a good test. It is possible that it is too free-burning where the draft is strong, but this may be remedied by mixing it with more caking coals. Whether this seam resembles the Briar Hill in its unequal distribution remains to be determined. The latter is found in local basins and is not evenly distributed over

large areas. Should the Jackson seam prove extensive and underlie the iron ore belt along the M. & C. R. R., and the Scioto and Hocking Valley Branch, ti will prove of incalculable value in smelting the abundant ores. From samples of the coal shown me I have little doubt that, in the hands of intelligent furnacemen, who have had experience in the use of bituminous coals in iron making, this coal will be found to answer an excellent purpose in the reduction of ores. Two furnaces, one at Jackson and the other near by, are soon to use this coal, and the experiment is likely to be tried under favorable auspices. The parties who have purchased the Diamond Furnace have successfully used the Briar Hill coal in the manufacture of iron, and will bring to the use of the Jackson coal, a large experience. The experiments which will doubtless be made in boring for petroleum will probably decide the extent and range of this seam of coal. I would suggest that careful records of wells be kept. At Jackson the coal is found from 30 to 40 feet below the surface of the valley. The dip is nearly east, and hence wells bored to the east, or in any direction having an easting from Jackson, would strike the coal at an increased depth. At Jackson the coal is three feet and nine inches in thickness and remarkably homogeneous in quality. If the coal before referred to, on Dr. Wolf's farm, northwest of McArthur, is the same coal, the presumption would be that the seam is continued over a large area.

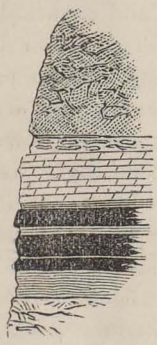
There are probably two seams of coal lying above the lowest seam and between it and the well known limestone coal. Near Hamden is a seam of coal which has been worked to a considerable extent. I had no opportunity of examining it. It is perhaps the equivalent to a seam of coal which lies from 40 to 70 feet below the limestone coal. This seam has considerable range and varies much in character. Where first seen, in coming to the surface, near Zaleski, it is somewhat impure and has generally been known as the "Splint Coal" seam. On the Vinton Furnace lands this seam is well developed and the coal is mined for domestic uses. It is 5 feet and 6 inches in thickness, from which are to be subtracted 9 or 10 inches of slate. This seam is probably found low in the hills in all that region. On the Buckeye Furnace lands, several miles south of Vinton, this seam is found changed into cannel. It continues as cannel probably over a considerable area. It has been mined, but chiefly by

"stripping," and the old excavations are now filled up so as to prevent measurements. The coal is of good quality, burns freely in the grate, and would doubtless answer a good purpose as a gas coal, and also for distillation into oil. If this coal seam continues westward, its place would be very high in the hills in the vicinity of Jackson. The "Howe seam," near Jackson, may be the equivalent; but to determine this, and similar questions of equivalency, further examination will be required. The "Howe" coal is excellent in quality, and has been highly valued. It is reported as between three and four feet thick.

The *Limestone Coal.* This seam of coal is of wide extent. I have seen it at various points from McArthur, north of the Marietta and Cincinnati Railroad, to the Ohio river, in the neighborhood of Ironton. At various places it is largely mined and serves a good purpose for ordinary uses.

This seam of coal lies under a seam of fossiliforous limestone, and upon the limestone rests the well known limestone ore. The following section will show the relation of these three strata which now play so important a part in the economic geology of Southern Ohio:

FIG. 1.



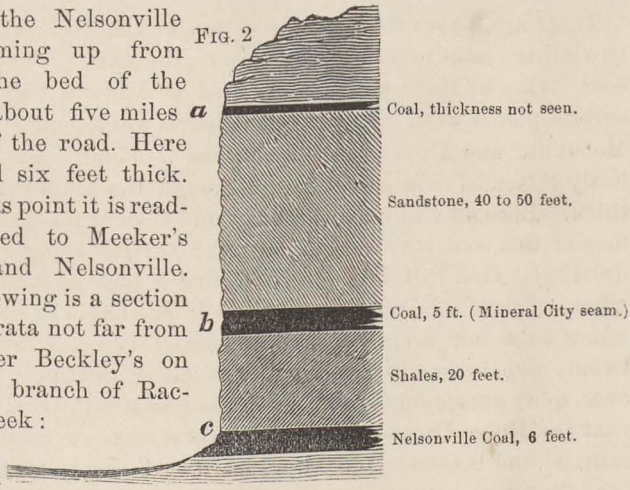
The coal seam is generally about four feet in thickness exclusive of slate. There is a parting of fire-clay about 10 inches near the top, and sometimes a thin parting, about two inches thick, near the bottom.

The ten inches of fire-clay serve for the "bearing in;" hence, in mining, the good coal on the bottom is saved. The upper part above the ten inches of slate is not regarded as very good, but it answers a tolerable purpose for grate use. The eighteen inches next below the ten inches fire-clay are used for smith purposes. Its proximity to the limestone ore makes it worthy of trial for making iron. This seam varies somewhat in different localities, but it is generally of fair working thickness, and from its wide extent it is destined to be very largely used in the several

counties through which it is found. The State geologists in 1838, regarded this seam as the equivalent of the Nelsonville coal. This equivalency is in my mind somewhat doubtful. The limestone coal receives its name from its association with a remarkably persistent seam of limestone which can be readily traced from the Ohio river to localities north of the Marietta and Cincinnati Railroad. Resting upon the limestone is the famous stratum of iron ore called the "limestone ore." In this ore we find a tendency to pass into flint. At McArthur it is a porous buhr, and is used for millstones. At Pomeroy, the buhr stratum, with the coal five feet in thickness under it, was passed in boring for salt, about six hundred and fifty feet below the Pomeroy seam of coal. This proves the wide range of the "limestone coal."

Nelsonville Coal. It is somewhat doubtful, as has been previously intimated, whether this seam of coal is well developed directly on the railroad. Its place would be not far below the seam now mined at Mineral City. If it is the continuation of the limestone coal, as our geologists have generally believed, then we have it well developed over a large area, as has been before shown. If its place is a little higher in the series it probably thins out in the immediate vicinity of the road. In passing up the east branch of Raccoon Creek from Mineral City, we find the Nelsonville coal coming up from below the bed of the stream about five miles north of the road. Here it is full six feet thick. From this point it is readily traced to Meeker's Creek and Nelsonville. The following is a section of the strata not far from Mr. Peter Beckley's on the east branch of Raccoon Creek:

FIG. 2



Two miles north of Mr. Beckley's, *b* and *c* are only eight feet apart. If the Nelsonville seam should be found about twenty or thirty feet below the seam now worked at Mineral City, (its

geological position,) it would rise into the hills on the Hope Furnace and Zaleski estates. On the Zaleski lands there is a seam of limestone on which rests a seam of ore. The limestone was, at the time of my visit, covered up, and I had no opportunity to determine by lithological and fossiliferous characters, its identity with the regular ore bearing limestone, which has elsewhere so wide a range. If it is thus identical, the position of the limestone coal seam would be just below it. I was led to believe that the true position of the Nelsonville coal would be higher in the Zaleski hills than the elevation at which the limestone is found. At Nelsonville, where the seam is largely mined, there is no limestone directly above the coal. At Chauncey, on the Hocking river, between Nelsonville and Athens, the Nelsonville coal is found by shafting at about one hundred feet below the surface. Here no limestone or buhr stone was found above it. At Chauncey the coal is six feet in thickness and is profitably mined for use in the salt furnaces. At Athens the same seam has been passed, in boring for salt, at a depth of about two hundred feet and a shaft is now being sunk for the purpose of mining it. The Nelsonville coal has a high reputation for quality, and it is extensively taken by canal to Columbus and other markets in that direction.

There are, above the proper position of the Nelsonville coal, two other seams as seen in the hills on the east branch of Raccoon. One of these seams is worked at Mineral City and at several points west. The coal at Mineral City, King's Switch, Moonville and Hope Furnace stations is of good quality, and justly esteemed as a grate coal, although the seam is not very thick. Like all coal seams directly under sandstone, the thickness of this coal is variable, the upper surface being quite undulating. Hence it is difficult to give a measurement of the seam which will be accepted by those interested in the lands and mines as a fair average. The Mineral City seam varies from twenty-two inches to five feet. The latter thickness is, however, quite exceptional. On the Zaleski estates the coal is mined near the Hope Furnace station, and at a location north of the railroad and between Hope Furnace and Zaleski stations. To the latter mines a branch railroad has been extended. The coal near Hope Furnace station is now being profitably mined by the Zaleski Company. I have seen no analysis of the coal, but from

its external appearance I think I cannot be mistaken in calling it a superior quality of coal for the parlor grate. At the other mines on the Zaleski lands two seams are worked. These are about sixty feet apart in vertical distance. The lower seam is three feet and a half thick, and the upper four and a half feet. The upper is the one principally mined at this time. The general quality of the Zaleski coals, of both seams, is excellent, and the coal is highly esteemed in Cincinnati for domestic uses. From the comparatively free burning character it is preferred for cooking stoves. It possesses the important elements of a parlor grate coal, and, properly tried, cannot fail to be popular.

Although mining operations have been attended with a reasonable measure of success, it is safe to say that success would have been far greater if the equipments of the railroad company had been such as to enable the mining company to transmit larger quantities of coal to Cincinnati, at such times as the market was unsupplied from the Ohio River, and the price consequently very high.

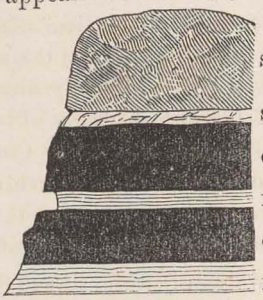
There is a seam of coal, reported to be four feet thick, appearing near the level of the railroad about three miles east of Athens. This is generally known as the Steiger Bank. This coal is mined at the present time. This is probably the same seam as that which shows itself at about the same elevation a few miles up the Hocking river, near the salt works of M. M. Green & Co. It has not been thoroughly opened at any point, but, from its position above surface drainage, it is worthy of investigation.

High in the hills, near Athens, is a thin seam of coal, of little economic value, which is probably the continuation of the "big vein" on Federal Creek. Judge Pruden's mine in the hills, not very far from Warren station on the railroad, is probably in the same seam. At this point the coal is not thick, but is profitably worked for the supply of the salt works in the neighborhood. This seam, however, attains its maximum thickness on Federal Creek and Marietta Run. On the latter stream a branch emptying into Federal Creek about a mile north of the railroad—this coal is ten feet thick. The coal is subdivided by a parting of fire-clay about one foot thick. There appears to be a local duplication of the regular seam, caused, doubtless, by a slight depression into which the waters brought and deposited fine sed-

iments, which now constitute the fire-clay. On this clay, as a floor, the upper coal was formed. A section of this remarkable seam presents the following appearance: FIG. 3.

The first few inches above the fire-clay is somewhat slaty but would doubtless answer for boiling salt and similar uses.

The rest of this large seam, say nine feet, is homogeneous in structure and excellent in quality.



The following is an analysis of the two portions, by Prof, J. S. Newberry, of Cleveland:

Lower portion.		Upper portion.	
Fixed Carbon	47.119	Fixed Carbon	48.010
Bitumen	45.781	Bitumen	44.855
Ashes	7.110	Ashes	7.135
	100.000		100.000

On Big Run, there is a seam of coal about sixty feet higher than the last. It is not yet developed.

To show the extent of the coal field which is being developed by your road, let us compare it with the most famous ones, probably, of the Old World. We quote from David Dale Owen: "The celebrated Newcastle coal field, which supplies more than one third the entire product of Great Britain, and from which most of the coal burnt in London is obtained, has an area of from seven to eight hundred square miles. The entire thickness of the measures is sixteen hundred and twenty feet, varying, however, in different parts. The total thickness of the twenty-five coal seams is from forty to sixty feet, the beds varying from a few inches to six feet; but there are seldom more than five seams that are workable, and often not more than one or two exist in a locality."

The Southern Ohio region, which is directly tributary to your road, is seventy-five miles in length and forty miles wide, making an area of three thousand square miles. Counting only those seams that are workable, we have over forty feet as the aggregate thickness. The total thickness of the Coal Measures in Ohio is about twelve hundred feet. Again, the principal seam of the Newcastle field is six feet thick, while one of the seams

of this region has a thickness of ten feet. In order to estimate the actual amount of coal in the field, and I am now considering only the out-crop, let us represent it by a stratum forty feet thick, 20 miles wide (allowing half the distance across the region for loss on the out-cropping strata) and 75 miles long. If, as is estimated, there are 1,000,000 tons of coal to one square mile of a layer one foot thick, there would be 40,000,000 tons to one square mile of this stratum, and multiplying by number of square miles, or 1,500, we have for the amount of coal 60,000,000,000 tons. These figures relate only to those seams which are for the most part above surface drainage. The presumption is that most of the seams continue under the surface of the coal basin and may be reached by shafts. It is by deep shafts that most of the coal in Great Britain is obtained. The total qauntity of coal in Southern Ohio which is accessible by drifting and shafting is almost beyond calculation, and the time will come when our coal will sustain large and busy mining and manufacturing cities.

IRON ORE.

By reference to the accompanying map the range of the productive iron ore measures will be readily seen. The conglomerate contains more or less iron. Sometimes the rock is merely stained by iron, and in other places the ore is found in small local deposits and may be regarded as heralding an iron period, soon to appear. In Kentucky there is a fine seam of ore resting above the sub-carboniferous limestone and below the conglomerate. This is finely developed upon the lands of the Daniel Boone Furnace Co. In Ohio the ores, beginning with the conglomerate, are found in several seams, interstratified with the sandstones, shales, &c. The most famous seam of ore, and the ore most worked, is the "limestone ore," which rests upon a remarkably persistent seam of fossiliferous limestone. Between the conglomerate and this limestone ore are several seams of "block ore," varying in thickness at different points. These often disappear and other seams take their places.

A section made by Seneca W. Ely, Esq., of a hill near Cincinnati Furnace, shows four seams of block ore, containing in the aggregate from twenty-six to thirty-eight inches. Some of this ore is poor, but much of it is valuable, especially when mixed with the limestone ore. At Jackson Furnace, Scioto county, there are three seams of ore called "Little Red," "Middle" or

"Sand Block" and Big Red," all lying considerably below the position of the limestone ore. The Harrison Furnace, which lies west of Jackson Furnace, in the same county, uses, from its own estate, block ores, of which a fine development in thickness and quality has recently been found. With this ore they mix an equal quantity of limestone ore, procured from their lands upon the railroad.

Several furnaces situated upon the western border of the iron belt, make their iron exclusively from the lower or block ores. The iron is said to be of excellent quality, and meets with a ready sale. Generally, those furnaces which have good block ores use them in preference as a mixture with the limestone ore. On the other hand, many furnaces which have an abundance of limestone ore are satisfied to let well enough alone, and prefer not to try any experiments in the way of mixing ores. The limestone ore, while it is no richer in iron than some of the selected block ores, is easily reduced and makes an iron of superior quality. The iron has a high reputation, and commands the highest market price. The drawback to this ore is the fact that, in some localities, it contains more or less flint. This difficulty only troubles certain localities, and the flinty ores can be easily rejected. It is a fact of no little scientific interest, that there was at the time of the deposition of the limestone, and the ore resting upon it, a struggle between carbonate of lime, and iron and flint for the ascendancy. In some places there is found almost nothing but limestone; in others the flint is wanting, and in still others the flint takes the place of both iron and lime. Where this flint is open and porous it constitutes a rough, ragged rock, which may be used as buhr stones for flouring mills. Formerly considerable numbers of millstones were quarried in the neighborhood of McArthur. I have known of most excellent stones, procured from these quarries. The limestone ore is generally thick enough to warrant digging; its thickness ranging from six inches to seven feet. When of the latter thickness it is a local development and is not of wide extent; but the seam is often found ranging from twelve to eighteen inches thick over large areas. At a few places the ore is obtained by drifting into the hills, but generally the surface soil is stripped off and the ore taken up as far into the hill as the disintergrating forces have made the superincumbent strata soft. The old rule has been to remove a foot of earth for each inch of ore. For ex-

ample, where the seam averages twelve inches, twelve feet of superincumbent earth may be profitably removed. This rule is not very strictly adhered to. It is probably safe to estimate that the limestone ore belt is twelve miles wide, from where, on the east, it disappears below the lowest valleys, to where it crops out on the tops of the highest hills on the west. Above the limestone ore are found two, and perhaps three seams of block ore, making in the aggregate about two feet in thickness. These seams are found in the hills along the eastern side of the ore belt. If we may estimate the aggregate thickness of the ores from the conglomorate to the limestone ore, including the latter, at five feet, we have for the whole ore belt seven feet of iron ore. In some localities the aggregate thickness will be ten or twelve feet. The ores vary in the per centage of metallic iron, but they range from thirty to fifty per cent. Chosen samples will yield sixty per cent. Selected limestone ore will make a ton of iron from two tons of ore. Generally, from the methods of digging the ore, it is somewhat dirty, and two tons and a half are allowed.

Thus far no black-band ore has been worked in Southern Ohio. In some localities the highly bituminous slate overlying the limestone coal is charged with iron, containing perhaps fifteen or twenty per cent. of that metal. If these overlying slates were carefully examined over this wide range of limestone coal, I have little doubt that at some points good black-band ore would be found. The fact that above the limestone the iron is abundant, and that the iron is often diffused through the limestone, making it ferriferous, gives a strong antecedent probability that at many places the black slates immediately below the limestone will be also largely charged with iron. Black-band ore might also be found at other points in the series of strata, either above or below the limestone coal, and all the black bituminous slates are worthy of careful examination. To aid somewhat in this, I give, as a sort of guide, the following group of strata, in which the black-band ore is found in Mahoning county, where it is extensively and profitably smelted:

	Ft.	In.		Ft.	In.
Iron ore, (Kidney ore)	0	6	to	1	6
Limestone	0	0	"	8	0
Shale	0	0	"	10	0
Coal	2	0	"	3	0
Black-band ore	0	8	"	2	0
Coal	0	5	"	1	0

Three and a half tons of black-band ore, in the raw state, make a ton of iron, but the ore varies in richness in different localities. This ore is very easily smelted, requiring but two-thirds the amount of fuel used for other ores. The iron made from it is peculiarly well adapted to castings, is very fluid when melted, and makes a smooth surface. I would remark that black-band ore will hardly be found in our ore measures in Southern Ohio, unless methods, less desultory and more intelligent, are employed in the search for ore than those now too often employed on our furnace estates. Generally, the finding of ores is left to accident, or to laborers, who are guided by no intelligence or system. The wonder is that on some of the furnace lands, such men should find ore at all.

The ores of Southern Ohio, are classed under carbonates and hematized carbonates. As has been previously stated, the seam of ore most prized is the limestone ore. This, in the out-crop, is a hydrated peroxide of iron, but further in the hill, where it has been excluded from atmospheric influences, it is probably a proto-carbonate, but often mixed with peroxide.

The ores of the lower coal measures are largely used in Pennsylvania, but Mr. J. P. Lesley, in his "Iron Manufacturer's Guide," says, "they will hardly bear comparison with those of the grander outspread of the same formations in Ohio, Kentucky and Western Virginia. * * * * It is these ores that have furnished in Southern Ohio the supplies for the numerous furnaces about Hanging Rock, and at other points, the iron from which has a reputation almost equal to that made from the genuine hematites of the metamorphic rocks. They abound more around the margins of the great coal fields where the lower members come to the surface, than in the middle portions."

It is a fact of no little interest, that the Marietta and Cincinnati Railroad, with its Portsmouth branch, opens to profitable development a very large portion of one of the finest iron regions in the world. Instead of crossing this iron belt directly, the road lingers in it as if loth to leave it. Going westward, the road enters the belt near Hope Furnace, then it takes a southern direction to Hamden, sixteen miles. Thence passing a little north of west the main road crosses the lower strata of the ore belt at right angles with the line of strike, and leaving the iron district a little west of Cincinnati Furnace.

The Portsmouth branch, leaving Hamden, runs towards the western edge of the belt at Jackson, and there enters the fields of the Jackson "shaft coal." Thence it passes toward the eastern side of the belt at Portland, offering the facilities of a good road to the many adjacent furnaces. Thence gradually bearing west it leaves the belt in the neighborhood of Sciotoville.

The probable extension of the Ironton Railroad, which is already more than half finished, meeting the Portsmouth branch a few miles west of Pioneer Furnace, will complete a line of railroad, extending for a distance of about seventy-five miles along this region of out-cropping strata of iron ore, giving to more than thirty furnaces in its immediate vicinity the advantage of ready transportation. No small importance should be attached to the fact that this road, carrying and distributing the limestone ores from the center of the belt to the furnaces on the west and east sides, where the block ores abound, facilitates a mixture of ores, which is considered so desirable by many furnace companies. As the Lake Superior ores are profitably used in the furnaces of Eastern Ohio, why may not the Missouri iron ores, from Iron Mountain, &c., of equal value, transported by railroad to St. Louis, then up the Ohio river to Portsmouth, and thence distributed by means of your railroad throughout this section, be also used with advantage in mixing with the ore of our coal measures ? The expense of transportation cannot be greater than that of bringing the Lake Superior ore to furnaces on the Ohio river above Wheeling, and to other points in Eastern Ohio.

The location of your road, viewed in the light of the iron district through which it passes, is most remarkable, and to be fully understood, the accompanying map should be carefully studied.

It may not be out of place in this general discussion of the inexhaustible ore beds of Southern Ohio to present the following extracts from a recent communication to the Chicago *Tribune*, from the pen of Prof. Daniels:

"An invention of vast importance to American mines and manufactures, and especially to those of Illinois, has recently been introduced by some of the enterprising citizens of Pittsburgh. After careful and thorough experiments its merits are now fully established, and it undoubtedly deserves to rank among the greatest discoveries of the age. It is essentially a

new method of generating and applying heat in the process of metallurgy, and is called the "Sieman Furnace." The inventor is a German who resides in England, where, as well as on the continent, the furnaces are being extensively and successfully worked. The principle is applicable to all the processes of reducing, refining and working metallic ores or metals, and indeed wherever heat in large quantities is required. The most valuable feature of this invention as applied to our western interests, is in its use of the poorer qualities of coal. The most sulphurous coal, and even the slack and waste of the mines are just as valuable in the Sieman Furnace as coals of the best quality, if they contain the same proportion of combustible matter. The sulphur and other impurities are rendered harmless by the mode of combustion, and the highest temperature possible is gained with wonderful economy of fuel."

The principle on which the required heat is obtained without bringing the iron in direct contact with the coal is one of the highest moment in making iron. Prof. Faraday, of England, the highest possible authority on such a subject, said, in a recent lecture before the Royal Institute: "The Sieman process is founded on philosophical principles and is destined to play an important part in all metallurgical operations."

Sir W. Armstrong, late President of the British Association for the Advancement of Science, and celebrated as the inventor of the Armstrong gun, also strongly commends the Sieman furnace.

Most of the furnace companies in Southern Ohio, have an abundance of coal on their lands. Should the Sieman method of making iron warrant the commendation it is reciving from practical iron men, the number of furnaces in Southern Ohio could be almost indefinitely increased. Now, to secure a permanent supply of charcoal, the companies own from five thousand to ten thousand acres of land. By the Sieman method of manufacture a few hundred acres of choice ore land with a seam of coal would be all the land required.

By an inspection of the horizontal section it will be seen that the iron ores are not confined to the limits of the iron belt where the ore seams crop out, but these seams doubtless extend through the whole range of the Ohio coal measures. The ores of the carboniferous formation in Great Britain, are almost exclusively obtained by shafts far below the surface of the ground.

Supposing the iron ores to extend uniformly over half of this belt, or seven and a half miles, and the length of that portion of the belt, included in this report, to be seventy-five miles, we have an area of five hundred and sixty-two square miles.

With an aggregate of seven feet of ore there would be 4,061,-986,133 cubic yards, which, according to the usual estimates, would yield 1,624,794,449 tons of metalic iron.

There are about forty furnaces in this region, consuming annually not far from two hundred thousand tons of ore, from which are made eighty thousand tons of iron.

At sixty-five dollars a ton, this would be worth five millions two hundred thousand dollars. The dividends of profits have, during the past year, been very large, ranging from twenty to nearly forty dollars a ton, when iron was seventy dollars.

The capacity of the furnaces ranges from ten to sixteen tons per day. The length of the blast depends upon the quantity of stock which can be accumulated. During the past year, labor has been scarce and high, and few furnaces have been worked up to their full capacity.

SALT.

The principal saliferous stratum is the conglomerate, which underlies the productive coal measures. But the salt is not confined to this rock, but may be found in the sandstone of the Waverly Series below, and also in the sandstones of the Coal Measures above; but the strongest and most abundant brine is found in the conglomerate. It was in this rock that the original salt springs were found, west of Jackson, in Jackson County, which were, in the first settlement of the State, reserved by the Government. To increase the strength of the brine, wells were bored. The salt-bearing rock dips to the east, and now it is customary to bore wells at points quite remote from the outcrop of the conglomerate, with the design of reaching the rock at greater depths, in the expectation of finding stronger brine.

The water percolates through the somewhat porous sandrock, dissolving out the particles of salt, and it is supposed that the brine increases in strength as it descends the inclined plane. Section No. 2 will explain the position and dip of the conglomerate.

From Jackson, or its equivalent position, near the Cincinnati Furnace, east along the line of the Railroad to Marietta, brine may doubtless be obtained anywhere by boring.

It might be strong enough for profitable evaporation at Jackson, but there can be little doubt as to the value of the brine at Zaleski, and almost anywhere east of that point. In the neighborhood of Athens, good brine is obtained at about seven hundred feet.

If the Federal Creek coal is the geological equivalent of the Pomeroy coal, as it doubtless is, we should certainly expect to find the salt rock at Big Run, Marietta Run and Federal Creek, and its tributaries, at the same distance below the surface as at Pomeroy, viz: about 1,000 feet.

A very deep well in the neighborhood of Pomeroy, has reached the depth of 1,245 feet, and has passed through the conglomerate and entered the fine grained or Waverly sandstone.

From Big, Run, the dip of the strata to the east cannot continue very far, since, by tracing the strata through Athens, Morgan and Washington Counties, I find that the thin coal at the Narrows, on the Ohio River below Harmar, under the heavy sand rock, is the equivalent of the Big Run or Federal Creek seam. Hence the bottom of the basin is reached not far from Big Run, and from that point to Harmar the strata are nearly horizontal, subject doubtless to some undulations. This fact is most important and determines the depth at which the conglomerate or salt rock will be reached in Washington County.

The three essential elements of profitable salt-making are, 1st, an abundance of good brine; 2d, fuel at minimum cost, and 3d, cheap transportation. The first of these can be obtained by boring to the salt or conglomerate rock. It is, however, generally believed that the deeper the conglomerate is struck, the stronger the brine. If this is so, the valley of the Hocking, near Athens, and the valley of Federal Creek, would be better locations than any farther west. Probably the latter locality would afford stronger brine than the former.

There is every geological reason to believe, that the brine on Federal Creek, and its tributaries near the railroad, would be quite as strong and the supply as abundant as that found at Pomeroy, since the coal seams in the two locations are equivalent and have the same relation to the underlying conglomerate.

The second element mentioned is found in the abundant Coal on the line of the Railroad. West of Mineral City, Coal is found in all the hills. In the valley of the Hocking, one seam of coal,

but little developed as yet, is found above drainage; but by shafting from one to two hundred feet, the Nelsonville seam of six feet in thickness can be obtained almost any where. The salt works on the Hocking have been in successful operation for many years. At Chancey, the Nelsonville coal is reached at a depth of about 100 feet below the surface. On Federal Creek and its tributaries, there is no limit to the supply of coal. On Marietta Run, a branch of Federal Creek, the coal is nearly ten feet thick, and is so situated that the cost of mining would be very trifling.

It should be remembered that for the purpose of boiling salt, the inferior and refuse coal of the mine, which would not be suitable for market, may be used. Should the coal mines in the region be extensively wrought, the cost of the fuel necessary for carrying on a very large salt business would be almost nothing.

The third element, viz: Cheap transportation, the Railroad would furnish. The salt could be taken to the Ohio River at Marietta and there shipped, or that destined to supply the market in the central and north-western parts of the State, could be taken to Athens and shipped by the canal to Columbus.

There are few locations in the world where all the essential elements of successful salt manufacture are so happily blended. At the Salines, near Syracuse, New York, while the brine is strong, the fuel is very expensive. At Saginaw, Michigan, the brine is strong and abundant, but the fuel used is wood, which, in its preparation and transportation to the salt works, is very costly compared with coal at the mouth of a coal mine.

For several years the salt business in Ohio has been very profitable, companies having, it is said, declared dividends ranging from 50 to 100 per cent. on their capital stock.

I am indebted to Hon. E. H. Moore, of Athens, Collector of Internal Revenue for this district (No. 15), for the following facts relative to salt:

There have been produced in the district, during the year 1864, 1,677,774 bushels of salt, from the tax on which the Government has received $41,011 68.

FIRE CLAY.

Besides the coal and iron ore there will doubtless be found valuable seams of Fire Clay. None of these seams have as yet been extensively worked. There is a heavy stratum of apparently excellent clay on the lands of the Harrison Furnace Company, near Sciotoville. The trials which have been made of this clay in the manufacture of fire-brick are said to have resulted most favorably, and there is now a prospect that suitable works will be erected in that neighborhood for using this clay. Careful search will doubtless be rewarded in finding other seams equally valuable.

PETROLEUM.

The geological relations of petroleum are not as easily understood as those of the great mineral products—coal and iron ore. The latter can be seen and measured, but petroleum is found in subterranean fissures, and hence the questions of locality and quantity are involved in no little obscurity. We have learned, however, in what geological strata the oil has thus far been found, and can therefore estimate the probabilities of finding oil in similar strata elsewhere. We have also learned to estimate the significance of surface indications, as shown in oil and gas springs, and in the inclination or uplifting of the strata by which subterranean fissures may have been produced.

The two geological formations from which, in the United States, oil has thus far been chiefly found, are the carboniferous and devonian. The oil now produced in Western Virginia and South-eastern Ohio is all found in the coal measures. The oil on Oil Creek, Pennsylvania, is derived from devonian rocks. There are, however, several locations in Western Pennsylvania, such as Smith's Ferry and Dunkard's Creek, which are in the coal measures. Fortunately, the M. & C. R. R. passes through both of these oil-producing formations. In the *carboniferous rocks* in Ohio, we already have remunerating oil wells in Washington, Noble, Morgan and Athens Counties. In these counties the more promising lands are in a state of transition from the hands of the farmers into those of men of capital and enterprize, and large results are hoped for. The geological positions of these counties is essentially the same. They all lie upon the upper part of our Ohio coal measures. Washington County, for the most part, is a little higher in position than the others.

If we take the Pomeroy coal-seam as our geological horizon, and follow that horizon through Meigs, Athens, Morgan, Noble and Washington Counties, we shall find that the principal part of the oil yet obtained has been found in strata lying from fifty to three hundred feet below that horizon. I state this simply as a fact. It would not be safe to infer from it that the oil is limited to these three hundred feet.

Very few wells have been bored very deep, and of these several have struck good veins of oil. The fact is significant, however, in revealing a very large area of oil territory of no little promise.

Other counties, besides those already named, lying upon the M. & C. R. R. and its Portsmouth Branch, are not without their claims to be good oil territory. Surface indications of oil are said to exist along the Raccoon and its tributaries, and on several other streams. I have not had time to investigate these indications, but there are no geological reasons why oil should not be found in the coal measures west of Athens County. Lands in that region are being sought after, and many wells will be bored to test them during the coming summer and fall.

The carboniferous strata, from Big Run, westward, are all inclined to the east or a little south of east. The amount of dip ranges from ten to forty feet per mile. The force causing this general uplift has doubtless produced many subterranean fissures. I have also found, as the result of instrumental surveys, marked undulations in the strata. These undulations would probably necessitate more or less fissures along their anticlinal and synclinal lines. Such undulations have been found in the vicinity of Big Run.

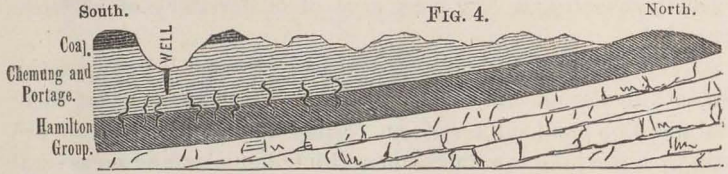
It is possible that in many cases the fissures have great vertical range and perhaps extend down through the carboniferous into the devonian rocks, in which case the oil is similar in origin to that on Oil Creek, Pennsylvania. This fact may be of great importance in determining the economical value of our oil fields.

THE DEVONIAN OIL FIELDS.

West of Cincinnati Furnace, in Vinton County, we enter the out-crop of the Waverly sandstones. Under this group lies the black slates, which crop out a little west of the city of Chillicothe.

By reference to the accompanying map the geographical and stratigraphical positions of these two members of the Devonian formation will be readily seen and understood. The Waverly sandstones are a group of the highest interest in an oil point of view, being the Ohio geological equivalents of the oil bearing rocks on Oil Creek, Pennsylvania, now the best developed and most productive oil region of the world. In order to understand the rocks on Oil Creek, I give a section showing the geological structure of that region.

FIG. 4.



Low down on Oil Creek the coal is seen on the tops of the highest hills. Underneath the coal measures are the Chemung and Portage rocks, chiefly sandstones. It is in these sandstones, and principally the "third sand rock," so called, that the largest oil fissures are found. Below the sandstones are the black bituminous slates of the Hamilton group. These black slates are rich in bitumen and consequently in oil, and the simplest and most scientific explanation of the origin of the oil is, that it is produced by distillation from these bituminous slates.

Doubtless large fissures extend down into these slates. The bituminous vapor rises in these fissures and a part is condensed into oil and part remains as gas. In boring wells these fissures are struck. If the fissure is penetrated favorably, the pent up gas forces the oil up, and there is a flowing well. The amount of bitumen in the black slates has been estimated to be greater than the aggregate of all the bituminous matter in all the coal seams of the coal measures. It is not therefore to be wondered at that there are on Oil Creek vast accumulations of oil.

Having thus briefly discussed the geological relations of the oil wells on Oil Creek, Pennsylvania, now the standard oil region of the world, the way is prepared to speak intelligently of the Ohio equivalents of the Pennsylvania rocks. The Oil Creek sandstones are readily traced westward into Ohio. At Mecca, Trumbull County, much valuable oil has been found in them. These rocks sweep around to the South, and pass down through Licking, Fairfield, Pickaway, Ross, Pike and Scioto Counties, entering Kentucky in Greenup and Lewis Counties.

By referring to the general geological section accompanying this report, these sandstones marked as "Waverly" will be seen, with the coal measures resting upon them to the east and the black slates underlying them. These slates are, in many places, rich in bitumen, and oil can be readily distilled from them.

I have not been able to investigate the question of surface indications of oil in all the counties above named, but at points between the M. & C. R. R. and the Ohio river, I have myself seen oil and gas springs. The surface oil proves that *some* oil has been distilled from the black slates, and come up through fissures to the surface.

The question of quantity alone remains to be determined. This depends upon the number and extent of the subterranean fissures, questions which wells alone can decide.

I have thus presented the geological evidences in favor of finding oil in the Waverly rocks.

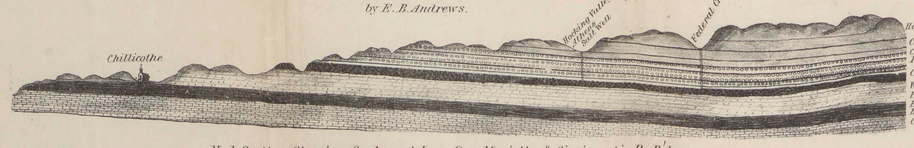
The supply of oil from Pennsylvania has been diminishing, while the demand is greatly increasing, and new oil fields are being sought for. It is certainly reasonable to hope to find other "oil creeks" in the geological equivalents of the original Oil Creek. These Ohio rocks are entirely undeveloped, but they are certainly worthy of being tested. Many years since I investigated the history of a salt well, bored forty-five years ago, near the mouth of Munn's Run, in Scioto County, and was led to believe, from the amount of oil and gas it had thrown up, that had the well, when first bored, been properly tubed and treated as an oil well, it would have been a flowing one. Large quantities of gas and some oil are now thrown up. This well is in the Waverly sandstones. Other salt wells in the vicinity revealed oil.

I have thus briefly noticed the leading objects of attraction in the economic geology of the region traversed by the M. & C. R. R. and its Portsmouth Branch. It was impossible to make the examination as minute and as full as I could desire. A *complete* examination of our vast mineral resources can only be made under the auspices of the State, in a geological survey, and this work would involve the labor of intelligent men for years. Such a survey should have been made twenty-five years ago, and the interests of our people have greatly suffered for the want of it. The mineral wealth of Ohio is enormous, and the

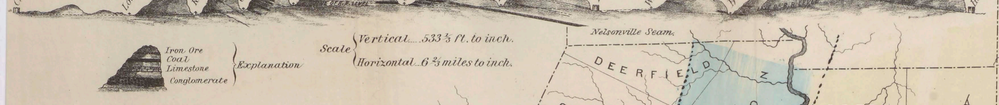
time is rapidly approaching when it will be appreciated and developed. Such vast resources as are found in the region tributary to the M. & C. R. R. will ere long give employment to a large mining and manufacturing population. There is no limit to these resources of salt, coal and iron, yet all grouped along one railroad.

By the present method of making iron with charcoal, tens of thousands of acres of the finest iron ore and coal lands are kept in forest. This will not continue, for the time is coming when the coal in our hills will melt the ores of our hills. Should the principle of the "Sieman furnace," already referred to, have the practical value which Professor Faraday and Sir W. Armstrong claim, the problem is solved. Should it fail, other methods will be tried until success is achieved. Then Zaleski, Jackson, Ironton and other places in the iron belt will become great business centres, whose iron manufactures shall rival the Pittsburghs of the new world and the Sheffields of the old.

No. 2. General Geological Section of Southern Ohio.
by E. B. Andrews.



No. 1. Section Showing Coal and Iron Ore. Marietta & Cincinnati R. Rd.



MAP OF THE MARIETTA & CINCINNATI R.R.

ITS CONNECTIONS AND LANDS TRIBUTARY.

Prepared by M^c GEE & PHILLIPS, Civ. Eng's, Marietta, O.
Geological Locations & Sections by E. B. ANDREWS, Geological Professor in Marietta College.
Scale 5 miles to 1 inch.

Middleton, Strobridge & Co. Cincinnati, O.

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